AIR MASS CHARACTERISATION DURING EOPACE: AEROSOL COMPOSITION AND CONCENTRATION

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Award No N00014-96-1-0321

LONG TERM GOALS

This project aims to define those air mass characteristics which impinge upon the performance of Navy electro-optical systems for a wide range of environmental conditions within the littoral zone. En route to achieving these goals, it is not feasible to monitor the environment to the required degree of spatial and temporal resolution, and the essentially single-point estimates available from existing models will clearly be inadequate. Therefore, other methods must be established and validated, with the long-term future probably resting upon mesoscale meteorological models incorporating aerosol loadings and which, to some extent, simulate the particle dynamics. Satellite imagery is being utilised to map aerosol optical depths with improved algorithms providing some size information, although this approach depends upon satellite availability, does not work in the presence of cloud cover, and lacks any predictive capability. It is necessary to ground-truth these methods, in addition to testing the validity of their assumptions and their extrapolation to other parts of the mapped areas, thus providing comprehensive information for the development and validation of mesoscale models incorporating aerosol sources, sinks and transport.

OBJECTIVES

The major objective of the current work has been to characterise the composition and concentration of the accumulation mode particles ($0.05 < r < 1.5\mu m$), for a variety of locations and environmental conditions within the littoral zone, by means of a thermal analytical technique. Soot carbon loadings have been measured within these coastal air masses both as a cross-check on the thermal analytical analysis and as a very useful means of defining the anthropogenic input into these air masses. Observations in the Southern California Bight on board RV *Point Sur* are being compared with estimates of particle size and optical depth derived from satellite retrieval methods.

APPROACH

The thermal analytical ('volatility') approach employed to determine the concentrations and composition of sub-micron aerosol particles consists of a Particle Measuring Systems ASASP-X optical

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Air Mass Characterisation during Eopace: Aerosol Composition and Concentration	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Sunderland,School of the Environment,Centre for Marine and Atmospheric Sciences,Sunderland SR2 7BW, UK,**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT	b ABSTRACT	c THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**5**	

particle counter, covering particle radii from 0.05 to 1.5μm, to which particles are supplied from a quartz heater tube capable of cycling through a temperature range from near ambient to close to 1000°C. The method relies upon the fact that most aerosol species become volatile at a characteristic temperature enabling the predominant components of the aerosol to be identified. While lacking the precision of many standard analytical techniques, this method is able to provide size-differentiated information on aerosol composition, giving it a powerful advantage over many other, more complex methods. The volatility technique has been used previously in the littoral zone (Smith and O'Dowd, 1995) where the ability to derive soot carbon measurements from the thermal response of the aerosol was demonstrated. However, because of the importance of these soot carbon measurements in indicating the impact of anthropogenic (principally vehicular and power plant) inputs within coastal air masses, a Magee Scientific aethalometer was deployed to measure this parameter independently.

Particles larger than about 1μm in radius were measured using two additional Particle Measuring Systems aerosol counters: an FSSP-100 and an OAP-230X covering particle radius ranges from 0.25 to 23.5μm, and 5 to 150μm, respectively. For the shore-based campaigns, these observations are being used in associated studies (and in combination with additional measurements) to define the surf zone contribution to littoral aerosol loadings but, in all the campaigns, they provide information on the complete particle size range of interest for infra-red propagation studies.

WORK COMPLETED

During FY97, air mass characteristics have been measured during four field campaigns, namely, shore-based measurements during November 1996 at the Naval Amphibious Base (NAB), San Diego, a brief campaign on RV *Point Sur* during March 1997, followed by shore-based measurements on the pier at Scripps Institution of Oceanography, and finally a further series of measurements at the Naval Amphibious Base during August/September 1997.

The NAB measurements were conducted at the head of the beach on the southeast side of San Diego bay, just above the high water mark and were made throughout the period from 4 to 21 November 1996, apart from the loss of about two days data near the end of the trial because of instrument problems arising from loss of power at the field site. A further series of measurements were conducted at this site during 23 August to 6 September 1997, again on a continuous basis apart from brief periods of down time required for routine instrument cleaning and maintenance.

The cruise on board the RV *Point Sur* ran from 11 to 20 March 1997, though measurements during the period from 16 to 19 March, inclusive, were severely hampered by the ship manoeuvrings required for the TDROP operations during this period. In the little time which remained, allowing for the passage times between Moss Landing and the Los Angeles area at the start and end of the cruise, the weather conditions were not especially co-operative. However, an interesting period occurred during the early part of the cruise where there appeared to be a relatively uniform gradient of aerosol concentration with distance offshore from the Santa Monica area.

Following this cruise, the instrumentation was transported to Scripps Institution of Oceanography for installation at the end of the pier, where measurements proceeded from 31 March to 11 April 1997, again with only brief interruptions for equipment maintenance. As for the earlier measurements at this site, during January 1996, strong diurnal changes in aerosol loadings were noted, although associated with generally greater synoptic variability than previously.

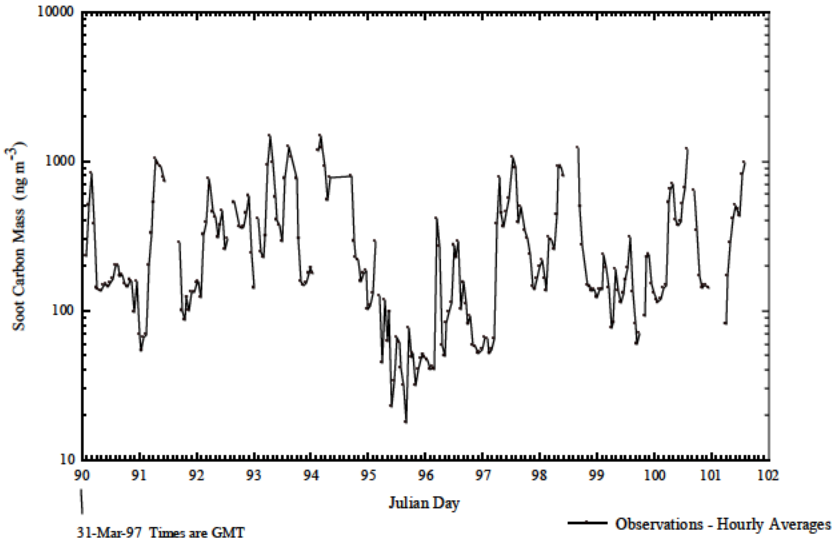
RESULTS

The heavy field work commitment outlined above has mean that much of the effort during FY97 has been concentrated upon undertaking the field measurements and maintaining the equipment during the 'off-periods'. However, the majority of the data has been checked and validated for availability (via the EOPACE Web facilities) to the other EOPACE participants. Detailed data analysis is now underway both to relate observations to environmental conditions as well as to correlate these observations to those of the other participants.

During the year, analysis continued on the data gathered during the 1996 cruise on RV *Point Sur* and was reported in two papers presented at the 1997 SPIE meeting (#3125) in San Diego. This work demonstrated the extreme variability of aerosol loadings within the littoral zone. While the strong anthropogenic loadings associated with outflow from the Los Angeles basin during Santa Ana conditions were to be anticipated, it was surprising to find that relatively clean, more oceanic air could be found within a few miles of these extreme aerosol concentrations.

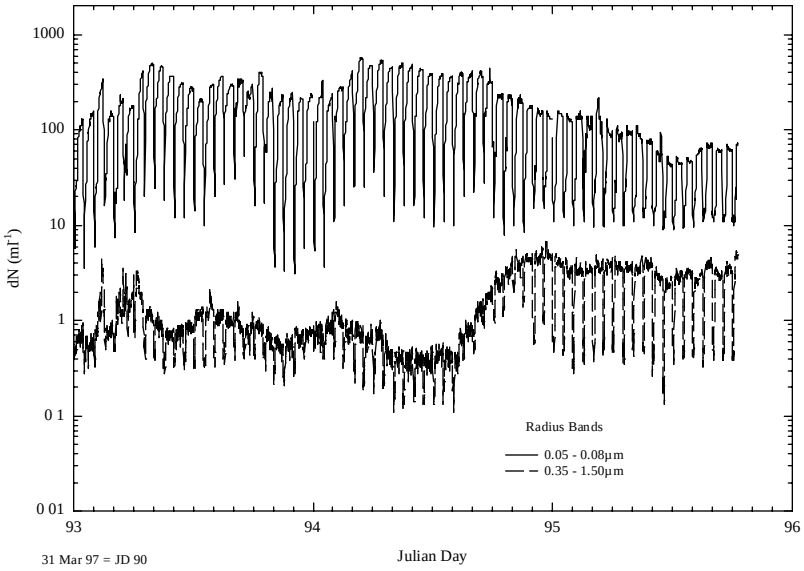
In all the shore-based measurement campaigns, diurnal land-sea breeze effects were found to have a major influence on air mass characteristics within the coastal zone, although these influences were moderated by synoptic scale meteorological processes. Thus, nocturnal off-shore flow would transport continental air, heavily influenced by anthropogenic inputs, out to sea bringing high aerosol loadings to the measurement site from urban areas in the hinterland. Typically, during the morning, the flow would reverse and this polluted air would flow inland, again passing the site, though with reducing aerosol concentrations due to dilution and loss processes in the off-shore area. Depending upon the specific conditions of flow rate and the general meteorological synopsis, relatively clean oceanic air might flow past the measurement site by late afternoon just prior to the evening reversal of the flow and a repeat of the cycle. These aerosol loadings would be moderated not only by the prevailing meteorology, but also by the local characteristics, such as rush hour traffic near Scripps pier and the NAB site, or by the nearby power station at Moss Landing. As an example of this process, the soot carbon loadings are shown in Figure 1 for the whole of the measurement period at Scripps pier. These observations show values of typically 1000ng m^{-3} for the overnight periods (graph times are GMT), representing moderately polluted conditions, with values generally approaching 100ng m^{-3} during the late afternoons. A change in synoptic conditions is evident through JD 94 to 96

Figure 1: Aethalometer soot carbon measurements at Scripps pier during the period from 31 March to 11 April 1997



where soot loadings approached very clean open ocean levels of 10ng m^{-3}. A temporal plot of volatility data through this period is shown in Figure 2 for the largest and smallest size fractions. It may be noted from this figure, that the steady decline in the smallest size fraction (dominated by the soot carbon aerosol) is mirrored by an increase in both the concentration and volatility of the largest size fraction, associated with the switch from land-based, mostly involatile, dust materials to more volatile sea salt as the strengthening winds brought in fresher, more oceanic air.

Figure 2: Aerosol volatility measurements for the period from 3 to 5 April 1997



IMPACT

This work emphasises that point measurements are likely to be of only limited benefit in defining the air mass characteristics within the littoral zone due to the high degree of variability encountered in such regions. However, the generally low loss rates of the accumulation mode particles which dominate air mass characteristics means that they remain mostly conserved within a given air mass (with allowances for changes in relative humidity). Hence, current mesoscale meteorological models should be capable of development to incorporate aerosol sources, sinks and transport processes in order to provide predictions of these air mass characteristics. These measurements are very useful in defining source strengths and providing a topographic map of aerosol for use in such mesoscale models.

TRANSITIONS

This investigation forms an element of the EOPACE programme whose aim is to characterise the atmospheric environment for the evaluation of electro-optical system performance.

RELATED PROJECTS

The UK Ministry of Defence provide funding via DERA Portsdown Contract No: SSDH300037 to cover participation in the surf zone studies which form an additional element of the EOPACE programme.

REFERENCES

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